research review

OAR: The Research Agency
of The United States Air Force

VOLUME III NUMBER 4 JUNE 1964

C3

Precursor of Geomagnetic Storms

HELEN R. BAKER *and* ALFRED E. REILLY, *Upper Atmosphere Physics Laboratory*, AFCRL

The onset of a geomagnetic storm may be announced several hours in advance by ionospheric changes--changes that can be detected by radio means. It may be possible to do this by analyzing a radio signal that has been reflected from the ionosphere over long oblique paths. These ionospheric changes also precede any changes in the earth's magnetic field detectable by magnetometers. Further, it may be possible to detect the occurrence of solar flares solely on the basis of ionospheric perturbations. Such advance warning can be of great usefulness in the operation of Air Force communication and detection systems.

These are some of the implications of an AFCRL study on ionospheric anomalies associated with solar flares and geomagnetic disturbances. That there is a correlation between solar flares, magnetic storms and disturbances of the ionosphere has been known for some time. But the nature of the ionospheric perturbations and their relationship to magnetic storms are not clearly understood. The AFCRL study deals with these relationships.

The recently completed AFCRL study is based on a series of experiments conducted in October 1962. For these experiments, four propagation paths were established between Hawaii and the continental United States. From a transmitter site at Pahoa, Hawaii, highly stable cw signals were transmitted in the 4 to 20 Mcps range. These signals, after multiple reflections from the ionosphere, were received at AFCRL in Bedford, Mass., at Jupiter, Florida, at El Paso, Texas, and at Ann Arbor, Michigan. The detected signal was analyzed from the standpoint of the fading rate and phase changes. The instrumentation, because of its extreme stability (1 part in 10^8), was capable of measuring in an unambiguous fashion the very minute variations in the parameters of the electromagnetic signal caused by ionospheric disturbances.

Most geomagnetic storms have their origin in solar flares--but not all solar flares produce geomagnetic storms. Solar-flare activity, in turn, is correlated with sunspot activity. The more sunspots present (the number may range from three or four to several hundred depending on the sunspot

cycle), the more likelihood of a solar flare. It takes about one day for the corpuscular stream from the flare to reach the earth's magnetic field, resulting in a geomagnetic disturbance. Why certain ionospheric anomalies seem to herald these disturbances is not known.

During October 1962, 29 major flares were recorded. The AFCRL propagation network was used to observe 26 of these, and all but one of the 26 produced ionospheric anomalies. Seven of the 25 measured anomalies occurred when geomagnetic storms were also in progress and thus were of limited interest. But 18 frequency anomalies occurred during solar-flare activity and in the absence of magnetic storms. Of the 18, 14 were unambiguous, and there was an easily observable degree of correlation among solar flares and propagation anomalies.

The other 4 (of the 18) represented special cases of special interest. These ionospheric anomalies occurred when the propagation paths were in total darkness. It was not expected that the propagation anomalies would occur during the night. In future work, particular attention should be given to such nighttime anomalies. This promises to be a fruitful area for a better theoretical understanding of ionospheric processes. But, more broadly, explanations are demanded and clearer relationships established for all aspects of the AFCRL observations. A thorough treatment should be of great theoretical and practical value. ★

research review
OFFICE OF AEROSPACE RESEARCH

PRECURSOR OF GEOMAGNETIC STORMS
Helen R. Baker and Alfred E. Reilly 1
INFRARED METEOROLOGICAL-SATELLITE SENSORS
Meteorology Laboratory 3
TARGET LOCATION UNDER LIMITED VISIBILITY
R. B. Toolin 4
SOLID HELIUM AND THE UNCERTAINTY PRINCIPLE
1st Lt William J. Mullin 6
WATER VAPOR IN THE VENUS ATMOSPHERE
Roger A. Van Tassel 8
RESEARCH IN MATHEMATICAL PROBLEMS
Captain John F. Gander 10
OPEN SEASON ON INFORMATION?
Rowena Swanson 12
NETWORK DESIGN VIA COMPUTER
Major Bernard S. Morgan, Jr. 17
NUCLEAR-STRUCTURE PHYSICS AT ARL
1st Lt Gale I. Harris 18
OPTIMAL UTILIZATION OF INDEXING PERSONNEL
Dr. Harold Wooster 22

OAR RESEARCH REVIEW is published monthly by the Office of Scientific and Technical Information (RRYC), Hq Office of Aerospace Research, USAF, 4th and Independence Avenue, S.W., Washington, D. C. 20333. The objective of this publication is to make a positive contribution to the exchange of information concerning Air Force conducted and sponsored research activities. Individuals or organizations interested in or associated with research may obtain copies without charge by written request to the above address.

OARRP 80-1

infrared meteorological-satellite sensors

METEOROLOGY LABORATORY, AFCRL

The TIROS II meteorology satellite carried an instrument which measured infrared radiation in the 6-6.5, 8-12, and 8-30 micron regions. It was hoped that this instrument would provide data which would eventually permit meteorologists to plot weather systems on a global basis, determine important cloud parameters, and monitor the earth's radiation into space for energy studies. Further, it was hoped that frontal systems could be mapped out quickly and automatically by feeding the data through a computer. The results were disappointing--disappointing in that the data on cold fronts and cloud heights plotted by the computer did not always agree with surface observations and pilot reports.

To explain these discrepancies, R. S. Hawkins of AFCRL has made a detailed study of one particular frontal system that developed over North America on 28-29 November 1960. This frontal system was observed during many orbits by the infrared detector on TIROS II. Hawkins' study involved, basically, a comparison of the computer-processed TIROS II data with unprocessed taped transmissions from the satellite. Both sets of data were compared with radar composites, surface reports, and radiosonde observations of the same storm. Results of the study are contained in a paper, "Analysis and Interpretation of TIROS II Infrared Radiation Measurements." In his paper, Hawkins offers explanations for the differences in data, and suggests that when these differences are understood and taken into account, infrared data from meteorological satellites can provide an invaluable tool for plotting and predicting the course of cold fronts.

The most important sources of errors in the computer analysis appear to be those due to excessive computer smoothing. The raw tapes were found to contain much more information than the computer made use of. It was shown that, if the same tapes were analyzed manually, cold-front patterns could be more precisely plotted. A second source of error was due to layers of thin cirrus clouds which sometimes obscured infrared detection of cloud systems directly associated with the frontal system. Lower cloud layers, by shielding reradiated heat from the earth, also confused the infrared detector, especially with respect to the determination of cloud heights. Mislocating of swaths due to incorrect determination of horizons and simple timing errors were additional sources of trouble.

When all the possible error sources are understood, however, it appears that infrared-radiation data from meteorological satellites may be useful not only for determining the location, motion and development of frontal systems, but also for obtaining information on the structure of frontal zones and regions of convective activity. ★

TARGET LOCATION UNDER LIMITED VISIBILITY

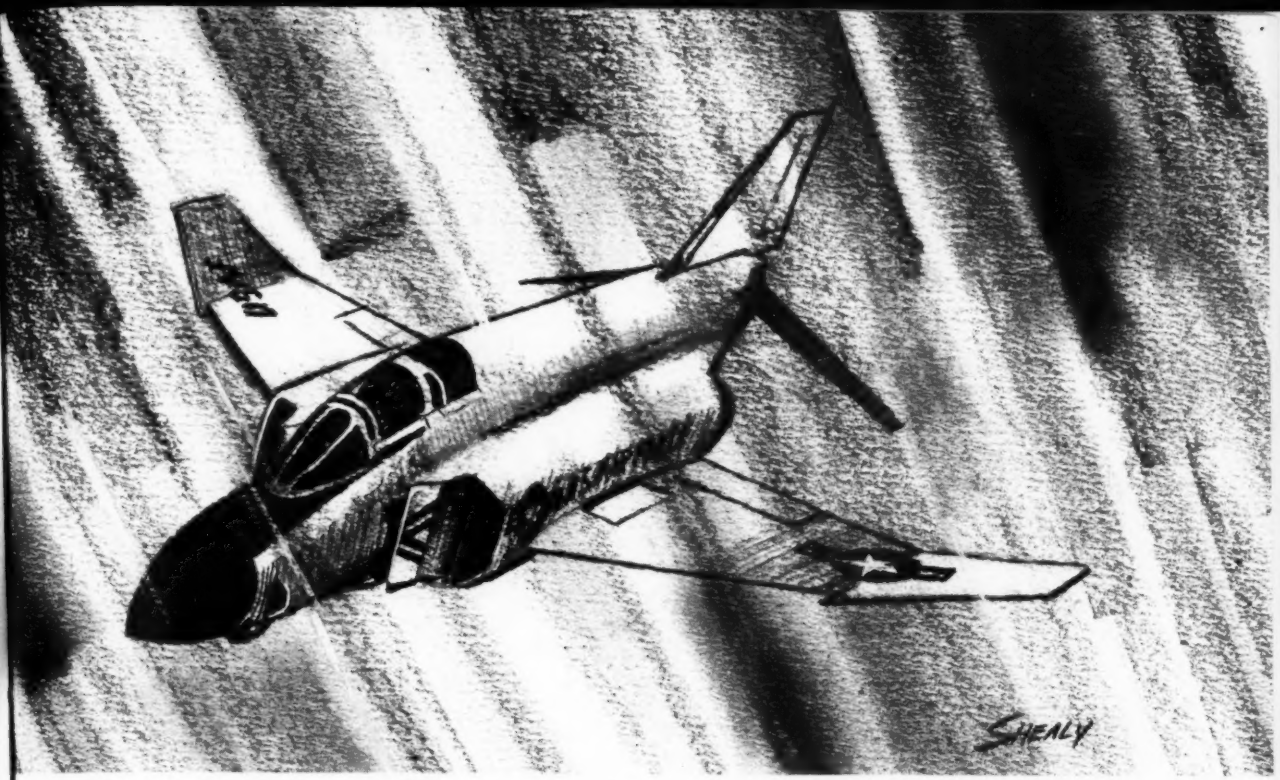
R. B. TOOLIN
Optical Physics Laboratory
AFCRL

All those who have navigated on a cross-country flight, whether flying a Piper Cub or a B-52, know that it is a simple matter to navigate visually on a clear, bright day. The navigational check points on the aerial map are easy to spot. They also know that, when visibility is limited and no electronic aids are available, it's just as easy to become disoriented and hopelessly lost. For a tactical fighter pilot on an interdiction mission relying on visual check points, the result is often an abortive mission or targeting error.

Before his mission, the tactical fighter pilot studies aerial reconnaissance photos and is told that he should expect so many miles of horizontal visibility. He does not know, except by rough guess, the distances at which he might be able to pick up such navigational features as a water tank, a forest clearing or a missile installation. The distances at which he may detect these features are strongly influenced by atmospheric conditions (haze, fog and so on), time of day (amount of light falling on objects of interest), the extent to which an object contrasts with its background, and the ability of the eye to adjust to changing conditions. But, if this tactical fighter pilot knows, for example, that at a distance of 20 miles he will be able to detect a certain navigational check point, navigational errors will be reduced and the probabilities of a successful interdiction mission will be greatly enhanced.

For the past three years, the Visibility Laboratory of the University of California, under sponsorship of AFCRL, has evaluated methods for furnishing the operational pilot with more precise and meaningful information on visibility conditions. The work is not concerned with the configuration of a particular reference point, or with its distance, but with its visibility threshold. As we have seen, a complexity of interrelating factors--atmospheric conditions, time of day, target background--enter into the problem. These present an infinite set of variables which must be properly weighed in terms of the known characteristics of human vision.

The establishment of visibility thresholds for all environmental conditions is the criti-



cal first step in the program--and it is here that present work is concentrated. Specifically, the program is concerned with the elimination of human test subjects on whom researchers in the field were forced to rely in establishing visibility thresholds. Such testing in the past has involved scores of test subjects spending countless hours of object identification under varying visibility conditions. The program has the goal of automating calculations for visibility predictions.

The University of California's Visibility Laboratory has developed two different classifiers for target indexing. The first and simpler of the two approaches is an optical system involving the transmission of light through transparencies of varying opacity. The second approach uses a computer to make the basic calculations.

In the first of the two techniques, a zoom lens is used to project an object, its model or its photograph, onto a transparency. The transparency has a variable transmission which is proportional to a chosen visual weighing function. A photomultiplier tube intercepts the transmitted radiation, and its output is proportional to the combined effect of this point of object space with the weighing function element. Rotating prisms transfer the image of the object space across the weighing function transparency. A second channel performs this same action for the background. The channel outputs are differenced to obtain the visual signal.

The other technique uses the projection of a photographic image onto a screen. Centered in the screen is a small variable aperture. The transmitted light is received by a photomultiplier tube. Its output, properly digitized, is recorded on IBM cards. The chosen weighing functions are also converted to computer language. The computer prints out the signal level for target indexing.

The computer must have stored on magnetic tape a large library of data concerning atmospheric effects typical of conditions in the operational area. The computer must also have available information concerning the optical properties of the terrains which constitute the target background. The computer program must include the dynamic aspects of the observer's environment. With the system, very comprehensive tactical problems can be studied quickly and inexpensively. ★

SOLID HELIUM and the UNCERTAINTY PRINCIPLE

1st Lt WILLIAM J. MULLIN
General Physics Research Laboratory, ARL

Since the atoms of the noble gases, helium, neon, argon, krypton, and xenon, have closed electronic shells, the details of their atomic structures are unimportant in any discussion of the solid phase of these elements. Indeed, it is possible to describe the interactions among a group of the atoms by means of a sum of two-particle interatomic potential functions. The potential energy of a system of these atoms is given by the Lennard-Jones potential

$$V = \sum_{i<j} v_{ij}$$

where $$v_{ij} = 4\epsilon \left[(\sigma/r_{ij})^{12} - (\sigma/r_{ij})^{6} \right] \qquad (1)$$

The distance between particles i and j is r_{ij}. The constants σ and ϵ are characteristic of the substance being described, and are usually determined by an experimental analysis of the gas phase. Their significance is shown in Fig. 1. The distance to the zero of potential is σ and the depth is $-\epsilon$.

Because of their simplicity, the noble elements are ideal for testing the basic postulates of quantum mechanics and solid-state physics. One of the most fundamental of quantum mechanical laws is the Heisenberg uncertainty principle. If the uncertainty in a measurement of the position of a particle is Δx, and the uncertainty in a simultaneous

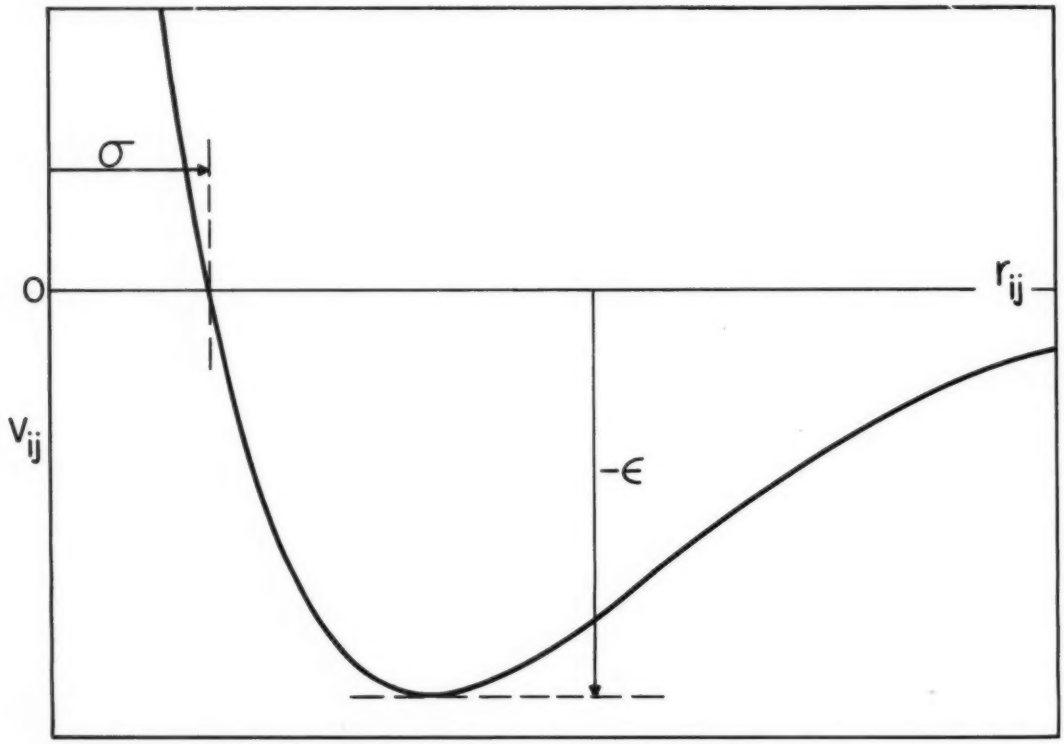


FIG. 1 Interatomic potential for a pair of noble gas atoms

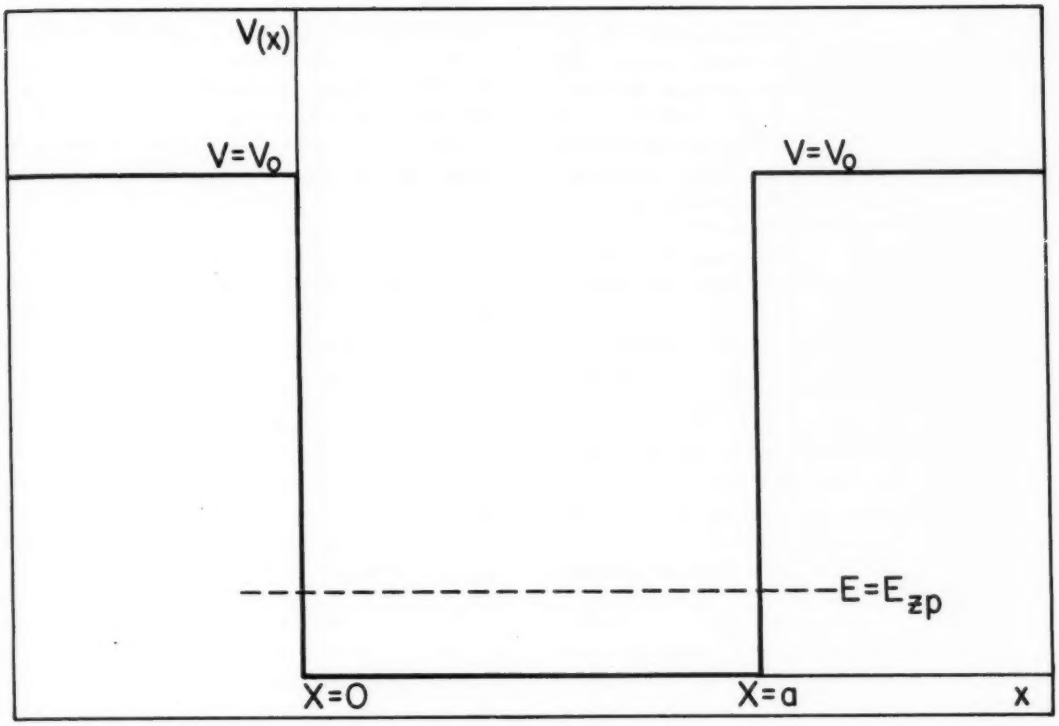


FIG. 2 Square potential well

measurement of momentum is Δp, then

$$(\Delta x)(\Delta p) \geq \hbar \qquad (2)$$

where $\hbar = h/2\pi$, and h is Planck's constant.

Thus, regardless of how accurate are our measuring devices, it is, in principle, impossible to specify simultaneously the momentum and position of a particle to an arbitrary precision.

The uncertainty principle leads directly to the phenomenon of "zero-point" energy. This is most easily seen by considering a particle trapped in the square potential well shown in Fig. 2. The uncertainty in position is clearly $\Delta x = a$. Hence

$$\Delta p \geq \hbar/a. \qquad (3)$$

The lowest possible energy allowed for the particle, the "zero-point" energy, E_{zp} satisfies

$$E_{zp} = p^2/2m, \qquad (4)$$

where m is the particle mass, and p is the magnitude of momentum. E_{zp} can, in principle, be known precisely so that the uncertainty in momentum stems only from an uncertainty in its direction; we do not know whether the particle is moving to the right or to the left. This means Δp is about twice the magnitude of momentum or

$$\Delta p \cong 2p \qquad (5)$$

so that from Eqs. (3), (4), and (5)

$$E_{zp} = \frac{1}{4}\frac{(\Delta p)^2}{2m} \geq \frac{1}{4}\frac{\hbar^2}{2ma^2} . \qquad (6)$$

A precise calculation for case $V_O = \infty$ yields

$$E_{zp} = \pi^2\hbar^2/2ma^2, \qquad (7)$$

which easily satisfies Eq. (6).

A similar argument may be applied to the potential given by Eq. (1). Each atom becomes trapped in a potential well created

by all the rest of the atoms. Thus, even at a temperature of $0^{\circ}K$., its kinetic energy will not vanish. The technique used to estimate the zero-point energy of the particle in the square potential well is not as simply applied in the case of the Lennard-Jones potential. As seen in Fig. 1, the width of the potential well and hence the position uncertainty varies with the value of the zero-point energy. However, an accurate quantum mechanical solution is possible.

The existence of zero-point energy has consequences which are subject to verification through experiments on the solidified noble gases. As indicated by Eq. (7), zero-point effects increase with decreasing mass, so that we can expect them to be most prominent in solid helium. Thus, the static lattice (that is, neglecting the zero-point energy) of solid He^3 would have a cohesive energy of about -24 cal./mole, whereas the experimental value is only -4.5 cal./mole! Thermal energy, if sufficiently large, causes melting in a solid; zero-point energy is somewhat analogous and, in fact, causes helium to remain a liquid even down to absolute zero. It is necessary to apply an external pressure of about 25 atm. to solidify liquid helium. In analogy to the expansion of a solid caused by thermal motion, the molar volume of solid helium at absolute zero is more than twice the static lattice value. Because its lattice has been expanded in this way, solid helium is expected to be an extremely compressible substance. Experiment bears this out.

One of the most interesting properties of solid He^3 is its nuclear magnetism. This property is present in He^3 but not He^4, because the nucleus of the former atom has a half-integral spin, and obeys the well-known Fermi-Dirac statistics, while the He^4 nucleus has zero spin and obeys Bose-Einstein statistics. This implies that solid He^3 may have a ferromagnetic behavior. However, the ferromagnetism arises from an alignment of the nuclear spins, not the spins of the outer atomic electrons as in the magnetic metals, such as iron. It can be shown that the degree of spin alignment from this cause is dependent on the amount of zero-point motion present in the solid. Thus, solid He^3 is the only substance in which this magnetic effect is measurable. It actually turns out that He^3 exhibits antiferromagnetism, that is, any two neighboring atoms in the lattice will be aligned with their spins in opposite directions.

The properties of solid He^3 are presently under theoretical investigation. Other solid noble elements have also been treated, and a paper by the author on the theory of solid neon at $0^{\circ}K$ will soon appear in the Physical Review.

WATER VAPOR IN THE VENUS ATMOSPHERE

ROGER A. VAN TASSEL, *Space Physics Laboratory*, AFCRL

The amount of water vapor in the Venus upper atmosphere is about the same as that found in the earth's upper atmosphere at comparable atmospheric-pressure levels. These results are based on a recent experiment conducted for AFCRL by the Johns Hopkins University.

The experiment was carried aloft from AFCRL's balloon-launch facility at Holloman AFB, New Mexico, on 21 February 1964. Measurements of the water vapor present above the reflective cloud layer of Venus were made with an automatic telescope of 12-in. aperture. The telescope was carried to an altitude of 87,500 feet. Radiation was measured at 1.13 microns with a grating spectrometer of two angstroms resolution. This portion of the spectrum was scanned once every ten seconds with a set of 21 exit slits arrayed to match 21 water-vapor-absorption line groups. The radiation passing through was received by a chilled photomultiplier and its response was recorded on paper.

Some 120 records were made during the flight. Analysis of the spectroscopic line groups shows that the modulation produced by water absorption is the same as that produced by 9.8×10^{-3} grams per square cm of water vapor at the earth's sea level pressure. The measurements are believed to be accurate to within five per cent.

Possible influence of water vapor in the earth's atmosphere above the balloon was assessed in two ways. Immediately after the observing period, and at the same altitude, radiation received from a piece of white cloth illuminated by the sun was analyzed. A much smaller modulation, resulting from water in the solar path, was measured.

Next, the influence of the Doppler shift on the recorded data was measured. The relative orbital motions of Venus and earth result in a shift in the spectral lines. The degree of shift was measured and found to agree with calculations.

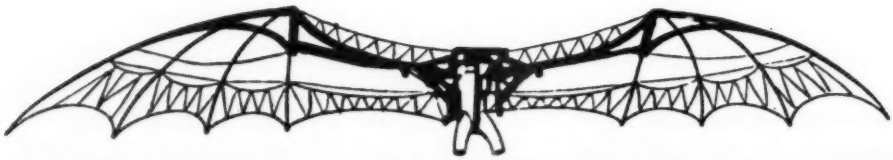
Both assessments are in fair agreement with the accepted value of about 0.7×10^{-3} g/cm^2 of water above the altitude of the balloon. Thus only about 1/20 of the modulation measured while observing Venus may be attributed to water in the earth's atmosphere or in the apparatus.

The interpretation of the measured absorption required certain assumptions about the pressures to be expected at and above the Venus cloud-top level, and the distribution of water vapor in this region. Pressure estimates range from 90 mb to 600 mb at the cloud level. The amounts of water vapor calculated at these base pressures are 22.2×10^{-3} g/cm^2 for the 90-mb case, and 5.2×10^{-3} g/cm^2 for the 600-mb case. It is interesting, however, to note that values reported for comparable levels in the earth's upper atmosphere represent the geometric mean of the extremes we have calculated for the planet Venus. ★

AFCRL notes

New Lunar Environment Chambers: Two new lunar-environment chambers in which temperatures, atmospheric pressures and radiations comparable to those found at the surface of the moon can be simulated have been placed in operation at AFCRL. The new chambers will augment a similar lunar-environment chamber that has been in operation at AFCRL for more than a year. Designed and built by Varian Associates, the chambers will achieve vacuums below 2×10^{-11} torr. Total volume of the working area of each chamber is about 15 cubic feet. A molecular-sieve roughing pump, an ion gettering pump and a titanium sublimation pump are combined to achieve the ultrahigh vacuums in the chambers. The chambers will be used in a number of studies of materials of the type believed to comprise the lunar surface. (Space Physics Laboratory)

Transatlantic Radio Ducts: On 20 February 1964, 425 Mcps radio signals were transmitted from Trinidad to Dakar, Africa, using a trade-winds ducting mode of propagation. This event represents the first time that radio signals were transmitted across the Atlantic by this mode. The distance between the transmitter and receiver is more than 3000 miles. The mode is created by a temperature-inversion layer which seems to be associated with trade-winds regions. The inversion layer creates a natural wave guide in which radio energy is channeled. During the late 1950's and early 1960's, AFCRL actively investigated this mode of propagation, using transmitting and receiving aircraft flying within the channel itself. These early experiments took place between Brazil and the Ascension Island. In recent years, little further investigation has been done. Transmissions were made by the USAF Trinidad 84-foot radar at 1 megawatt peak power. Signals were received at Dakar using a 20-foot dish of the Centre National d'Études des Telecommunications. (Upper Atmosphere Physics Laboratory)



RESEARCH in MATHEMATICAL PROBLEMS

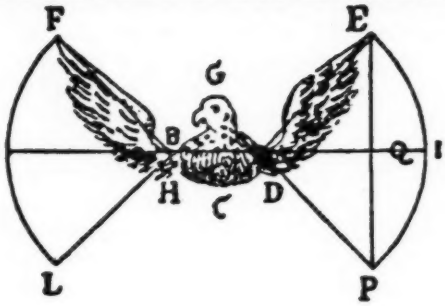
CAPTAIN JOHN F. GANDER
Directorate of Mathematical Sciences, AFOSR

"For many parts of nature can neither be invented with sufficient subtlety, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity without the aid and intervention of mathematics."

--FRANCIS BACON

Electromagnetic theory affords us an illustration of the power of mathematics to unearth nature's secrets. It was possible to conceive of, and even to visualize the airplane long before technicians produced working models. (Near the end of the 15th century, Leonardo da Vinci conceived and designed a flying machine.) On the other hand, the notion of a radio wave would hardly occur even perchance. Such types of electromagnetic waves, whose physical nature is still not understood, were discovered, nay, were invented because mathematical reasoning demanded their existence.

It is especially significant to note here that it was not just ordinary mathematical reasoning which led to the prediction of the particular type of electromagnetic wave, say, the radio wave or the radar wave. It was rather a demand for exact reasoning. The mathematician, valuing logical consistency in his equations above all else, does not allow his position to be prejudiced by the slightest contradiction. He allows no deficiency of physical understanding limited by human fallible and finite sense perception to divert him from his true course. He takes the steps necessary to remove the inconsistency. Filled with the spirit of exact reasoning, the mathematician considers no demand on behalf of exactness too great; he cannot afford "frugality" in his reasoning.



In no case is our ignorance of the real world or of its ultimate nature more shocking than when considering the phenomenon of electromagnetic theory itself. As an example, consider light. It is in the visible portion of the whole electromagnetic-wave spectrum.

There is no doubt but that something travels through space when light from one source, such as the sun, illuminates an object on the earth. But what is this something? For centuries scientists have been investigating light, and indeed the whole spectrum of electromagnetic waves. Mathematical laws provide the only means for probing and mastering this region of the physical world. Though the answers to these questions are unsatisfactory to the uninitiated layman, the consequences are miraculous. The military application of radar to the present complexion of warfare is but one small consequence.

The essence of any modern physical theory is a body of mathematical equations. The differential equations that were once the servant of physical thought have now become its master. At present, the Mathematics Division of AFOSR is partially supporting an outstanding group of mathematicians at NYU's Courant Institute of Mathematical Sciences under the able leadership of the Director of the Division of Electromagnetic Research, Professor Morris Kline. Within the scope of this AFOSR grant, and under the direction of Professor Kline, the group is presently

concerned with the general mathematical fields of ordinary differential equations, partial differential equations, and special functions arising from an intensive study of electromagnetic theory.

Some recent publications of this group deserve mention, for they are but another addition to our ever-growing fountain of knowledge from which have sprung such phenomena as radio, television and radar, not to mention the more sophisticated weapons-guidance systems of the present day. These new findings will not in themselves be singled out as producing this new system or that new system; but they may serve as the kernel engendering some future weapons system. Nor shall I detract from them by pretending to realize the many branches of science and technology that will draw on this new mathematical knowledge.

One such article by D. Cohen[1] studies the two-dimensional reduced wave equation in various domains. Impedance-type boundary conditions are imposed on any boundary, and a radiation condition is imposed in unbounded regions. The paper typifies the direction of present-day efforts to gain a better understanding of the boundary-value problems arising in communication and guidance-control theory.

In another publication by R. Lewis,[2] a system of ordinary differential equations is studied. However, instead of considering the usual initial value problem associated with this particular system of equations, the author considers the problem of characterizing the space of solution vectors which satisfy an orthogonality condition. This problem has particular interest in electromagnetic theory. The linearized ray equation of geometric optics takes the form of the equation studied, and the orthogonality conditions imposed are a statement of the fact that the rays and wave front are orthogonal (perpendicular). This is typical of wave-propagation problems such as antenna radiation, etc.

In another paper M. Machover,[3] using a model of the finite-dimensional case, extends the applicability of the method of separation of variables to a class of partial differential equations by including generalized eigenfunctions for the purpose of completion. (Here completion refers to the mathematical completeness of the eigenfunction expansions, a necessary requirement for the method of separation of variables.) Recall that, when the method of separation of variables is applied to solve a partial differential equation, it is assumed that the solution is expanded in a series of eigenfunctions of one of the variables. The coefficients depend upon the other variables. When the series is substituted into the partial differential equation, the coefficients are found to satisfy a new equation in one less variable than the original partial differential equation. By systematically exploiting this procedure, the problem of solving partial differential equations is reduced to problems of solving ordinary differential equations. Such a method could lend itself to other branches of physics, acoustics, aerodynamics, hydrodynamics, magnetohydrodynamics and quantum mechanics, which also treat wave theories.

We have come a long way from the time when Maxwell made his deduction based on the inconsistency existing between the electromagnetic theory of his time and the law of mathematical physics known as the equation of continuity. To a mathematician a contradiction is intolerable, and Maxwell resolved this difficulty. Could James Clark Maxwell have had any realization of the significance of his research? Indeed, have we yet realized its full potential? ★

REFERENCES:

1. *Cohen, D., "Separation of Variables and Alternative Representations for Non-self-adjoint Boundary Value Problems." To appear in Communications on Pure and Applied Mathematics.*
2. *Lewis, R., "On a Typical Problem for Linear Ordinary Differential Equations." To appear in Communications on Pure and Applied Mathematics.*
3. *Machover, M., "Generalized Eigenvectors and Separation of Variables." To appear in Transactions of the American Mathematical Society.*

open season on information

ROWENA SWANSON
Directorate of Information Sciences, AFOSR

We know what we know, but we don't know what we could know that's known. Daily we act on what we know and, inexorably, daily we discover facts we should have known for previous actions.

An early hypnosis induced by the availability of computers--that these so-called "giant brains" could solve the information problem--was soon dispelled by the realization that these mechanical marvels could do only what they were told to do, in full detail. Where were the instructions for identifying and organizing information, for coding and storing it, and for retrieving selected items from storage?

Information systems and system requirements have been analyzed to the point where instructions can be written for machines to perform the clerical aspects of storage and retrieval. A recent report of experts notes that automation of bibliographic processing, catalog searching, and document retrieval is technically and economically feasible now for large research libraries.[1] Yet increasing emphasis is being placed on information-systems research. Why? This is summed up in the acronym, G I G O (garbage in, garbage out). We must not only tell machines how to process, but also what to process. We must give machines the terms to process and specify the relationships, equivalents, and trade-offs to be made among terms. Terms which are not adequately descriptive of content, are not properly interrelated, or are not accurately assigned, glut information channels from the input to the output end. Research is on the trail of maximal information flow.

A primary target of research is the vocabulary of an information system. Much effort is being concentrated on the design of word lists, thesauri, and classifications. One of the most ambitious projects is that of the Engineers Joint Council (EJC), a body representing 29 engineering societies. A study of almost 14,000 terms selected from the terminologies of 18 organizations is being completed with the preparation of a Thesaurus of Engineering Terminology.[2] Major contributors to the EJC project have been representatives from the Institute of Electrical and Electronic Engineers (IEEE) and its Information Retrieval Committee chaired by Dr. Morris Rubinoff of the Moore School of Electrical Engineering, University of Pennsylvania. Dr. Rubinoff's activities derive from efforts he began at the Moore School which have been sponsored, in part, by AF-AFOSR-190-63 and AF 49(638)-1252.

The AFOSR study has spanned an historical period in information-system design. In October 1961, the Association for Computing Machinery (ACM) announced a search for organizations interested in providing a home for ACM repository materials, including unpublished documents and programs in the information-processing field. In February 1962, the Moore School was designated, and plans were drawn up for a system compatible with that of the extensive Moore School

collection. The transaction provided a unique opportunity to establish an information system for information-processing materials with experts from the information-sciences community. The Moore School formed an Advisory Committee of 14 experts with Dr. Rubinoff as chairman to consider the system-design problem. AFOSR implemented the research phase in November 1962.[3] Progress of the effort was reported to ACM members by Dr. J. G. Brainerd, director of the Moore School, and the ACM president, Dr. Alan Perlis, in Communications of the ACM.[4]

Results of the AFOSR study are reflected in achievements of the IEEE Information Retrieval Committee reported to the membership at the 1964 IEEE International Convention in New York. This Committee is guiding a program among several of the IEEE Professional Technical Groups which includes the development of effective indexing and abstracting procedures, language standardization, and information dissemination. The program plans to satisfy the two primary types of information needs: current awareness and retrospective search. An eventual goal is a network of mechanized specialized information centers with electronic interconnection and direct user access via typewriter-type keyboards.[5] "Microthesaurus"[6] concepts developed in the AFOSR study are being considered for the IEEE system.

On the education front, the American Society for Engineering Education (ASEE) plans coordination of the information needs of its membership with those of the IEEE, ACM, and EJC. The ASEE Information Retrieval Committee, also chaired by Dr. Rubinoff, is considering the following education-oriented items: (a) the utility of a lecture course in information retrieval in the undergraduate curriculum; (b) a program to provide engineering faculties with information on information resources; and (c) methods of assisting engineering-school administrators and librarians to prepare for the changing character of engineering libraries resulting from mechanization, including the use of display techniques.

Implicit in the exploration of information-system designs and structures is the requirement that adequate data bases be established for testing promising systems. Dr. Rubinoff has found no scarcity of volunteer help from IEEE and ACM; but lack of funds has prevented the most effective use of the volunteers. The no man's land between basic research and implementation was discussed at the 1964 IEEE Information Retrieval session by Dr. J. Hilary Kelley of the Office of Science and Technology, Executive Office of the President. The coupling promoted by Dr. Rubinoff with relatively token AFOSR support is leading to the possibility of diversified experimentation on information systems, and the ultimate promise of maximizing use of our national information resources. ★

REFERENCES:

1. *King, Gilbert W., Harold P. Edmundson, Merrill M. Flood, Manfred Kochen, Richard L. Libby, Don R. Swanson, and Alexander Wylly, Automation and the Library of Congress, Washington, D.C.: Library of Congress, 1963. (Available from the U.S. Govt. Printing Office, $2 per copy)*

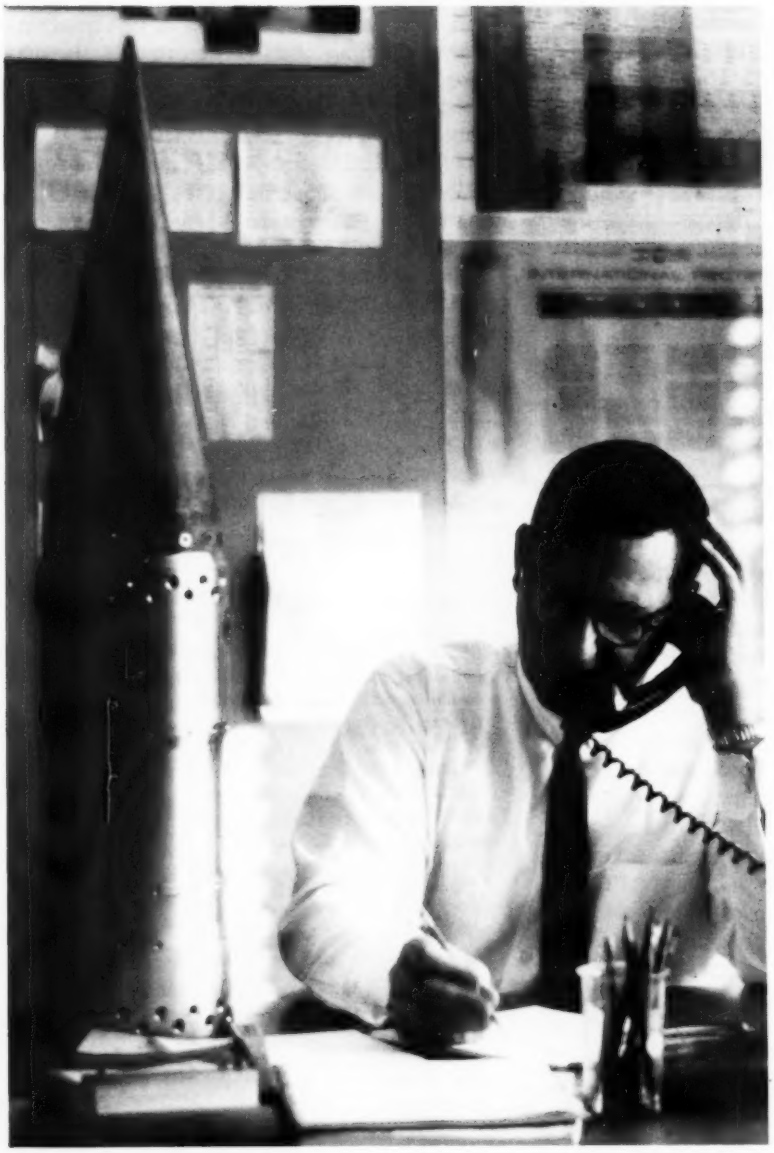
2. *Wall, Eugene, "Study of Engineering Terminology and Relationships Among Engineering Terms," Final rept., Aug. 63. NSF Grant G24836 with the Engineers Joint Council.*

3. *This information facility could be the central reference source to state-of-the-art knowledge on "software." With increasing emphasis on software for new command-and-control and intelligence-and-reconnaissance packages (see Missiles and Rockets, 30 Mar. 64, pp. 79, 87), improved accessibility to known information is becoming a sine qua non.*

4. *Communications of the ACM, vol. 6, no. 4, Apr. 63, pp. 142-3.*

5. *"Information Retrieval in IEEE." An interim report of the IEEE Information Retrieval Committee, distributed at the IEEE International Convention, New York, 24 March 1964. Also see: "Abbreviated Glossary of Information Retrieval Terminology," "Information Retrieval Catalog Cards," and "A Reading List on Information Retrieval" distributed at the same time.*

6. *"Microthesaurus" is defined as a thesaurus which provides deep or detailed indexing of a narrow subject field.*



Dr. Norman W. Rosenberg, Chief, Chemical Physics Branch, Upper Atmosphere Physics Laboratory, AFCRL, is presently engaged in work on upper-atmosphere processes, through techniques of chemical release. He has executed studies of artificial electron clouds and missile-trail phenomenology. He is currently considering problems of mass transport and reaction cross sections in chemical perturbation of the upper atmosphere. Dr. Rosenberg has a Ph.D. from Harvard (1949) and has been with AFCRL since 1959. He has several publications to his credit, and is a member of the American Chemical Society.

PROFILES

1st Lt Gale I. Harris, a scientist at ARL, has been doing work in both experimental nuclear physics and theoretical nuclear physics. In the former, he is conducting a comprehensive study of the structure of the P^{31} nucleus. Lt Harris has a Ph.D. degree in physics from the University of Kansas (1962), and M.S. and B.S. degrees from the same university. He has a number of scientific publications to his credit. In this Review, he writes on "Nuclear-Structure Physics at ARL."

1st Lt William J. Mullin, a scientist at ARL, is currently using a quantum mechanical variational technique to calculate the heats of sublimation and other thermodynamic properties of the solidified inert gases at 0° Kelvin. He has a B.S. degree from St. Louis University (1956), and is currently working for his Ph.D. degree in Physics at Washington University. In this issue of the Review, he writes on "Solid Helium and the Uncertainty Principle."

Dr. Herbert Payne, a scientist at ARL, has developed a formula which relates the density of fermions in a one-dimensional system in the ground state to the potential energy assigned to the system in the one-particle approximation. He has sought recently to either derive this formula for general mathematical concepts or define its range of applicability. Dr. Payne received his Ph.D. degree at Ohio State University (1953). He has been an Associate Professor at the University of Detroit and worked in private industry. He has a number of scientific publications to his credit.

Dr. Hari K. Sen is a senior scientist with the Space Physics Laboratory, AFCRL. In his current research efforts, he is working within the general field of magnetogasdynamics, including shock-wave theory. He has also done classified work on fireball physics and unclassified work on the theories of shock-wave structure. In the latter field, he has made a notable contribution with the theoretical discovery of an oscillatory fine structure in shock waves. Dr. Sen has an M. Sc. degree (1927) and a Dr. Phil. degree in astrophysics (1943), both from the University College of Science, Allahabad, India. In addition, he has an LL.B degree from the University School of Law, Allahabad (1929). Dr. Sen has numerous publications to his credit, and is a member of several professional societies.

Dr. Ernst R. Czerlinsky, Chief, Solid Physics Branch, Solid State Sciences Laboratory, AFCRL, does research on basic phenomena working with ferromagnetic materials, X-ray diffraction, structure determination and semiconducting materials. He is presently engaged in investigation concerning internal magnetic-field effect studies, recoilless gamma-ray absorption studies, and the thermal behavior of selected materials. He has the degree of Dr. Phil. from Koenigsburg University, Germany (1931), and has a number of publications to his credit. Dr. Czerlinsky is a member of the American Institute of Physics.

Mr. Sheldon B. Herskovitz, Chief, Gaseous Electronics Section, Solid State Sciences Laboratory, AFCRL, is currently directing research dealing with the interaction of matter and energy with ionized gases, with major interest centered on the production of plasmas and the determination of ionized media properties. Presently, several experiments on diagnostics and applications are being pursued. Mr. Herskovitz has a B.S. in chemistry from M.I.T. (1951) and an M.A. in chemistry from Harvard University (1955). He is a member of the Institute of Radio Engineers and The American Physical Society.

network design via computer

MAJOR BERNARD S. MORGAN, JR.
Directorate of Mathematical Sciences, AFOSR

The digital computer has, in the past five years, emerged as a useful tool in the design of electrical networks. At an elementary level, this consists in programming a computer to set up the "node" or "loop" equations describing a network, and then to solve the equations to obtain the circuit output. With the speed of modern computers, the output of many prospective circuit designs can be compared and the design thus optimized before any "breadboarding" is begun.

One might next consider the possibility of the computer generating its own prospective circuits, after being instructed in what constitutes a "good" design (or, in formal terms, an optimization criterion). As part of a research program in active network synthesis, sponsored by the Applied Mathematics Division, AFOSR, Professor Donald A. Calahan of the University of Illinois has considered such a possibility.

Professor Calahan's recent investigation into the development of such a computer technique has yielded an approach quite general in application.[1] The process begins by assuming the designer has a circuit with the desired transfer function (i.e., yields the output desired), but which contains elements that, for one reason or another, are not obtainable. Beginning with such a design, the computer proceeds to generate equivalent networks (ones with precisely the same transfer function as the original), each network with element values slightly different from the preceding. Tables of element values are then examined and the design with the most desirable values chosen.

The new technique has been applied to the classical problem of the design of filters which allow for the loss always present in inductors. Tables of element values were generated for such "lossy" filters, all filters having the same transfer function, but each allowing for slightly more loss than the preceding. These tables[2] are unique in the area of filter design; similar tables offer the promise of bridging the gap between much of modern network theory and the circuit designer who historically has neither the time nor background to investigate the involved theory.

A second application was in the design of transistorized filters. Realizing, as above, that one would like to use available or off-the-shelf transistors in design, tables of elemental values of equivalent filters were generated. The interesting feature here is that not all element values need be changed in accommodating for different transistors; in fact, in a simple filter, most elements can be fixed, and only a couple elements chosen as "alignment" elements.

The method offers such promise in turning out vast amounts of design information that the problem becomes one of choosing practical optimization criteria. For example, one might be more concerned with obtaining filters with equal element values than with "lossy" inductors, or with low-sensitivity active filters than with using available transistors. Both criteria can be accommodated from this equivalence approach.

Presently, investigations are being carried out to improve the computational efficiency in order to reduce the computer time required to generate such tables, and to obtain experimental verification in order to devise practical-design criteria consistent with this equivalence approach. In the future, it is planned to extend the theory to time-varying networks and to problems in control theory. ★

1. *Calahan, D. A., "Computer Generation of Equivalent Networks," to be published in 1964 IEEE Convention Record.*

2. *Calahan, D. A., "Tables of Elemental Values For Low-Pass Filters in Inductors Only," University of Illinois Report.*

NUCLEAR-STRUCTURE PHYSICS at ARL

1st Lt GALE I. HARRIS
General Physics Research Laboratory, ARL

The study of the structure of the atom's nucleus is an aspect of the more general investigation of the structure of matter which has, in some way, occupied the mind of man for centuries. Some of the other aspects of this more general investigation can be referred to with terms such as cosmological structure, solid-state physics, atomic structure and chemistry, and fundamental-particle structure or high-energy physics.

Nuclear-Structure Physics had its beginnings in this century when, in 1911, Rutherford discovered that the atom had a small massive core of positive charge which he called the nucleus. More than 20 years later it was shown that the nucleus, in turn, consisted of protons and neutrons, and possibly mesons as the binding agent.

During this period, also, the development of quantum mechanics took place. A framework was thus provided for a proper theoretical understanding of the rapidly growing body of experimentally observed nuclear-structure phenomena. During the following 10 years enough basic knowledge, however crude by today's standards, was accumulated to provide a basis for the technological development of the atomic bomb.

It was apparent even at that time, however, that there was actually very little understanding of the basic structure of the nucleus. Atomic weaponry, after all, required only a somewhat-crude picture of a liquid-drop nucleus which was unstable against fission if enough energy were provided by an impinging neutron.

The obstacles to progress in understanding were enormous, and primarily had to do with the fact that the nucleus is a many-body system with no well-defined center of force as in atomic structure; also, the fact that the basic internucleon forces were not understood and obviously very complicated.

The only real hope for the situation seemed to lie in the fact that general physical laws, such as the conservation of energy and momentum, and other symmetry properties of nature, still appeared to hold. (It was, in fact, for his development and application of these symmetry properties to nuclear phenomena that Eugene Wigner shared half the Nobel prize in physics in 1963.)

In 1949, however, and during the early 1950's a major breakthrough in understanding took place with the introduction by Meyer and Jenson of the nuclear-shell model. (They shared the other half of the Nobel prize of 1963 for that discovery.)

The ideas of the shell model were almost impossible to accept at first because they represented the antithesis of earlier ideas. The basis of the shell model was that each of the nucleons actually move in independent orbits under the influence of an average potential due to the rest of the nucleons. This implies in some way that the nucleus is a rather rarefied medium in which the mean-free-path of an individual nucleon is rather large. This is in obvious contrast to a liquid-drop model in which the nucleons must surely be constantly bumping into each other.

However, the fact that the shell model immediately gave an accurate description of important properties of ground states of almost all known nuclei could not be denied. There are also many other predictions of the shell model which are remarkably consistent with experimental fact.

In spite of the remarkable successes of the shell model, however, it became apparent to the people who were using particle accelerators to study the excited energy levels of nuclei that the shell model as originally proposed was inadequate to describe all the detailed properties of states being observed. For example, the cross sections for certain

nuclear reactions, electromagnetic transition probabilities, angular momenta of excited states, and other properties observed by means of accelerators indicated that the orbits actually get mixed up considerably, and that in many cases a sort of liquid-drop (collective) motion was taking place.

It now appears that the truth lies somewhere in between a liquid-drop picture and a true shell-model picture. In many cases, for example, it appears that simple orbits exist, but at the same time they are perturbed by rotational or vibrational motion of the rest of the nucleons taken as a whole. Such a picture is referred to as the unified model, for obvious reasons.

It is a major program of today's nuclear-structure physics to fill in the links between the two opposing pictures and try, if possible, to arrive at a truly unified model of nuclear structure. It is conceivable that a theory may be developed in which the liquid-drop and ordinary shell models are only special cases which describe certain subsets of observed phenomena.

At this point it seems appropriate to allude to a specific problem on which ARL and others have been working during the past three months. ARL has been studying for some time the excited energy levels of the P^{31} nucleus which are formed when we bombard Si^{30} targets with certain, well-defined-energy proton beams from a 2-MeV Van de Graaff accelerator. When the proton beam is tuned to certain precise energies, excited states, known as resonance levels, are formed in P^{31} as evidenced by sudden, spectacular increases in the yield of gamma radiation from the target. The situation is shown in Fig. 1.

The measurements shown in this figure were done about 3 years ago. Earlier this year this curve was extended up to proton energies of about 2.25 MeV, and a resonance was discovered at 2.187 MeV which was obviously different from the rest. It was at

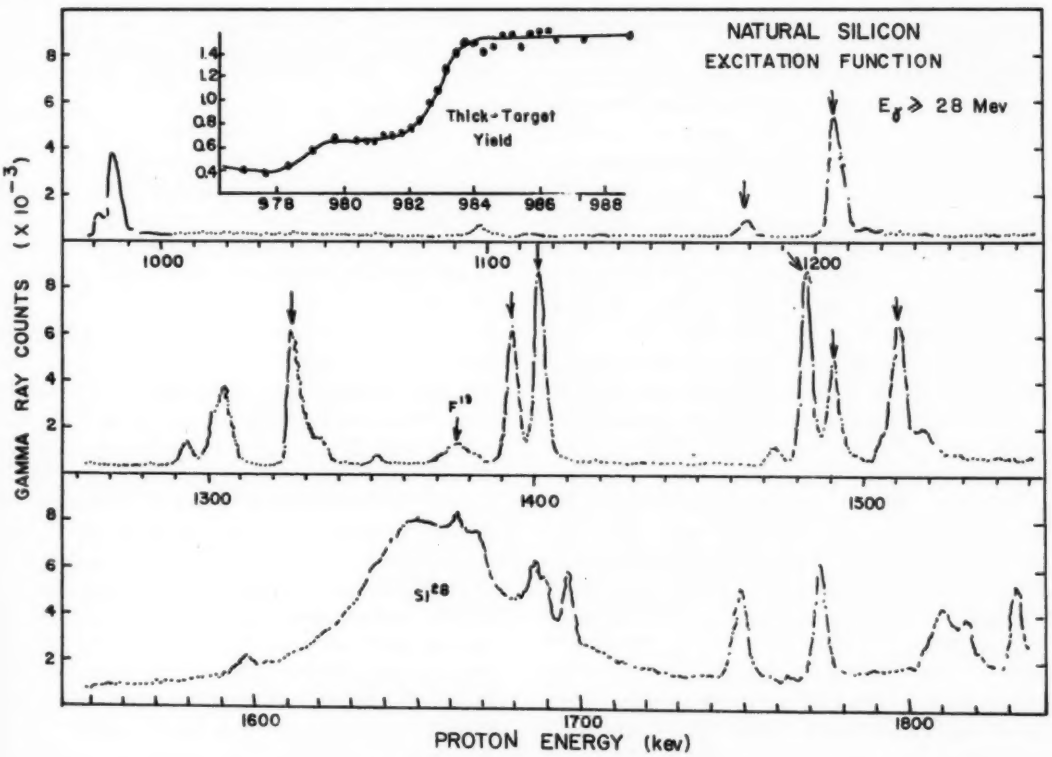


Fig. 1 Natural Silicon Yield Curve

least 3 times stronger than the rest, had an experimentally observable true width, and decayed by gamma-ray emission in a peculiar manner; that is, instead of decaying to many lower-lying energy levels as do all other resonances observed, it decayed only to one rather energetic state at 4.43 MeV in P^{31}.

In early September 1963, ARL performed a series of spectroscopic measurements, such as energy spectra, angular distribution and triple correlation studies, and intensity measurements on the emitted gamma rays from that resonance.

During the past few weeks the analysis of these measurements has been completed, and it is now clear that the resonance is very probably one of the so-called, single-particle levels predicted by the shell model. The angular momentum, parity, and reduced proton width of the level all support a conclusion that the situation can be roughly described as a proton in an orbit with 3 units of angular momentum about a core which is identifiable with the Si^{30} target nucleus. The spin of the proton and its orbital angular momentum are parallel, and the nucleus gets rid of part of its excess energy by the proton's simply jumping from one orbit to another with the emission of a pure dipole gamma-ray quantum.

There is at the same time, however, some evidence in the data that the Si^{30} core is not entirely inert--it is probably also undergoing some sort of vibration or rotation as the proton whirls around in its orbit.

Thus this appears to be a rather remarkable illustration of the general comments made earlier about connections between nuclear models. It seems that, by the proper combinations of simple ideas, one can explain away many observed facts. Unfortunately, this is not always the case. In general, many, many more measurements of this type are needed to provide a firmer foundation for the development of a proper understanding.

The experiment just discussed is representative of the kind of work being done with the ARL 2-MeV accelerator. ARL is specifically looking for information which bears upon the validity of proposed nuclear models for the region between oxygen and calcium in the periodic table. There are two reasons for ARL's concentration on this region: 1) it lies in a relatively unexplored region between the closing of two major shells of the shell model; and 2) it is very difficult to systematically study nuclei heavier than Ca with a 2-MeV machine because of the coulomb barrier between the incoming projectile and the target nucleus. Higher bombarding energies would be required.

During the past several months ARL has studied, in varying degrees of detail, excited states of Si^{28}, P^{30}, P^{31}, Al^{28}, Cl^{33}, Cl^{34}, Cl^{35}, and Ca^{40}. In general, properties have been observed which appear to be attributable to structure predicted by several variations of the shell and collective models. It appears, in particular, that the properties of many of the excited levels of P^{31} can be thought of as an orbital proton coupled to an asymmetrically deformed Si^{30} core. One can also imagine tidal waves set up on the surface of the Si^{30} nucleus by the orbiting proton; but this is certainly too naive.

As already mentioned ARL is, however, limited for all practical purposes to the lower end of the periodic table of elements by the 2-MeV capability of its present facility. In addition, and perhaps even more importantly, the investigation is restricted by nuclear-reaction kinematic considerations to a very small class of reactions which can be utilized to study these effects.

ARL is very fortunate in that early this year there occurred a rather radical change in accelerator-design concepts which would allow the construction of an 8-MeV accelerator with unique beam-current and energy-stability capabilities. The general idea consists of putting two 4-MeV machines in tandem (which is not in itself a new idea); but instead of using a conventional belt charging system to furnish the high voltage for the acceleration process, a 4-MeV ICT transformer is used to supply the terminal voltage directly. The advantages of this system were immediately obvious in terms of increased stability and beam-current output, plus the 4-fold increase in available energy range.

Fig. 2 Partially constructed 3-MeV ICT Transformer

ARL was also fortunate in that it was in a position to move quickly and get construction by the High Voltage Engineering Corporation (HVEC) on the first of these new accelerators. It is now clear that this action will put ARL in the position of having a unique capability in this area of research.

Fig. 2 shows a view of a 3-MeV ICT transformer now under construction at the HVEC plant. ARL's will be similar in appearance but slightly larger in diameter.

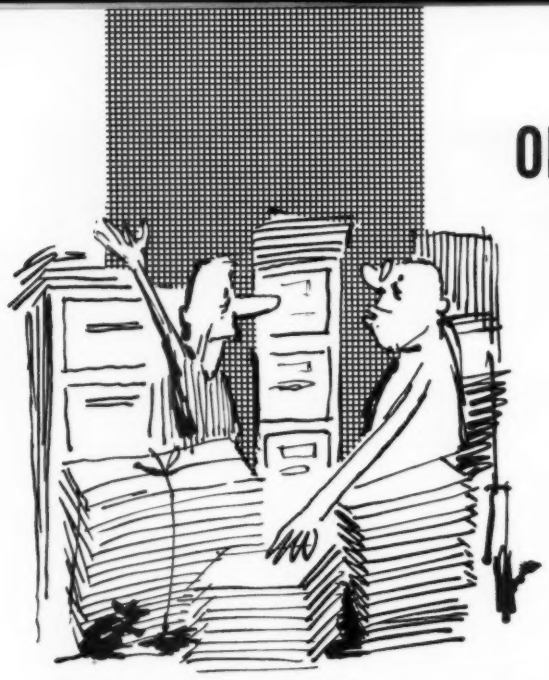
The combination of this machine and the present 2-MeV machine will provide a continuously variable range of beam energies between 0.3 and 8 MeV and, with current capabilities, surpass any such facility now in existence. The flexibility of the facility will be particularly useful. For example, the new machine can be operated either in tandem mode or in a single-stage mode, allowing the energy to be precisely set anywhere between 1.5 and 8 MeV. The machine can also be equipped with a special ion source to produce 3-MeV electron beams at 20 milliamperes of current. Operated in this mode, it would be the most powerful machine radiation source ever built.

For the immediate future, however, the machines will continue to be used to accelerate positively charged nuclear particles in a continuing program aimed at gaining a more complete understanding of the basic structure of nuclear matter.

In conclusion, one area of immediate interest to ARL is the use of a high-precision beta-ray spectrometer, now under construction, with the 8-MeV machine to study in a systematic manner excited states produced in nuclei heavier than calcium. This particular approach has not been exploited elsewhere to any significant extent, primarily because of either accelerator-energy or beam-current limitations. Again, ARL should be in a unique position to gain significant information by the exploitation of this capability. ★

OPTIMAL UTILIZATION OF INDEXING PERSONNEL

DR. HAROLD WOOSTER
Directorate of Information Sciences, AFOSR



Indexing is the process of assigning to a document, or set of marks on paper, another somewhat smaller set of marks, presumably related in some fashion to the intellectual content of the original document, to help you find it when you want to.

This is a Least Common Definition. Almost everyone will agree that indexing is a Good Thing; but from this humble starting point protagonists of various indexing methods can only agree to disagree. Arguments rage up and down the descriptive continuum between the hierarchs of, say, Universal Decimal Classification and the anarchs of Uniterm with the thesaurian squirarchy trying, hazardously, to keep a foot in each of the opposing camps.

Indexing, at least in the foreseeable future, must be done by people (and, by the way, for people--a point all too frequently overlooked in the discussion of Indexing as an Art Form). And the question of just who should put the bells on the Document opens up a whole new family of arguments, inseparable from theoretical discussions of indexing schemata, but compounded by such actual problems as Personnel Availability, Training, Monotony and Money. Some contend that proper indexing can be done only by a GS-15 Subject Specialist, furnished with a science doctorate, postgraduate training in Library Science, and an elaborate bibliographic armamentarium of authority lists (personal, corporate and subject), classification skedules (sic) (the spelling is deliberate, the advocates British), and a brand-new but well-thumbed Thesaurus. Others claim that all that is really needed is an intelligent but uninformed GS-3 clerk typist, equipped with a red pencil and told to underline all the words she doesn't know.

"War," wrote Georges Clemenceau, "is too serious a matter to be entrusted to the generals." Indexing, we are told, is too serious a matter to be entrusted to professional indexers. Only professional scientists (who, although it is all too often forgotten, are at best amateur indexers) can be entrusted to index their own papers with "keywords taken from standard thesauri." Librarians, who quite properly view subject cataloging as one of the most skilled aspects of their undersung profession ("I love to catalog," Elsie said, Dewey-eyed) stand aghast if not speechless at this barbarian invasion of their cluttered sancta.

Facts are hard to come by in this welter of claims and counterclaims, polemics and apologetics. Few of those concerned with operating information systems in the real world of money and manpower, Forms 57 and P 690 funds, start out with blank checks, an infinite supply of highly trained yet docile professionals, and unlimited computer time at zero cost. We must make do with what we can get, and learn by the hard-won experiences of others, if they will tell us.

Saul Herner of Herner & Co., Washington, D.C., under AFOSR Contract AF 49(638)-1182, has reported to the Division of Chemical Literature, American Chemical Society, at the Philadelphia Spring Meeting of this year, his actual experiences with six indexing projects. Some of his conclusions are summarized below:

Case A

The problem: To index reports in chemical engineering and polymer chemistry with an existing word-indexing system based on words derived from text.

The approach: A professionally trained indexer built an authority list of vocabulary of indexing terms to start the system. Nontechnical, nontrained indexers were then given a month's training period.

The findings: "We found that there is a tendency toward excessively individualistic indexing among persons with higher levels of academic training. This apparently arises from the fact that the more educated indexers become more absorbed, and sometimes overabsorbed, with the textual content of what they are indexing. . . . Where strict word indexing is involved, persons of lesser education are likely to equal and possibly exceed persons of higher education."

Case B

The problem: Uniterm indexing of biological literature.

The approach: Professionally trained biologists did the indexing.

The findings: Morale and indexing rate dropped off. The biologists were replaced with high-level clerical personnel. The clerical personnel outproduced the trained personnel and the quality of their work was higher. "We found a definite feeling of intellectual downgrading among the more highly-skilled personnel assigned to do the Uniterm indexing . . . in using such personnel for word indexing we were not only inducing a poorer product, but we were disaffecting and exposing ourselves to the possible loss of valuable personnel in whose training we had invested large sums of money."

Case C

The problem: Indexing literature in a medical field (cerebrovascular diseases) with indexing words selected from titles in Index Medicus.

The approach: Start with high-level clerical personnel and work up the professional ladder.

The findings: "As we went up the scale of professional training and experience, we found a greater and greater tendency to 'bind' or relate words in titles and to show logical combinations where they existed. Thus we verged from mere word indexing to the beginnings of concept indexing."

Case D

The problem: To use an existing good thesaurus for indexing petroleum literature.

The approach: Not to pester the scientific side of the house wantonly.

The findings: The thesaurus showed the relationships between terms in such detail that, although the literature dealt with chemistry and chemical engineering, the use of persons trained in these fields was limited to a minority of cases where the indexers couldn't understand the terms or they were not in the thesaurus. Thus the technical people were saved for the most technical jobs.

Case E

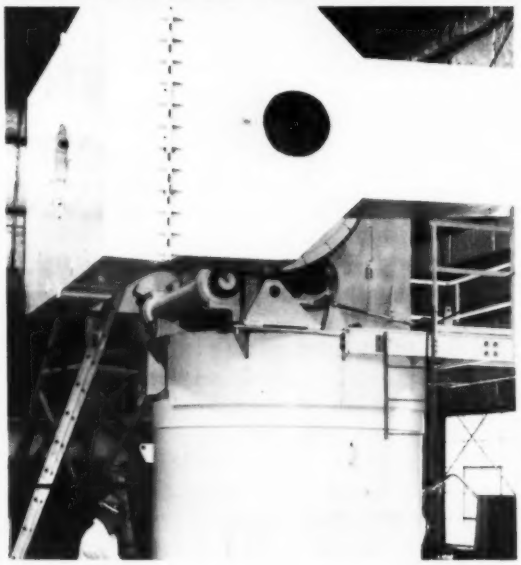
The problem: Expanding an existing file of medical effects of organic chemical compounds.

The approach: Incoming compounds were divided into those which were already either in the file or in Chemical Abstracts, and those which were not.

The findings: Nonchemists could deal with old compounds; M.S. organic chemists were needed only for new compounds.

In this burgeoning world of scientific and technical information, highly trained, professionally competent indexers are scarce and expensive. They are hard to get and, if used the wrong way, may be even harder to keep. As Herner's paper points out, the popular belief that the better trained the man, the better job he will do, is not necessarily so. Or, in more formal language:

"From the viewpoint of technical quality, employee morale, and simple economics, it behooves the indexing-system designer and manager to perform thorough analyses to determine the lowest level of personnel capable of doing each indexing task." ★



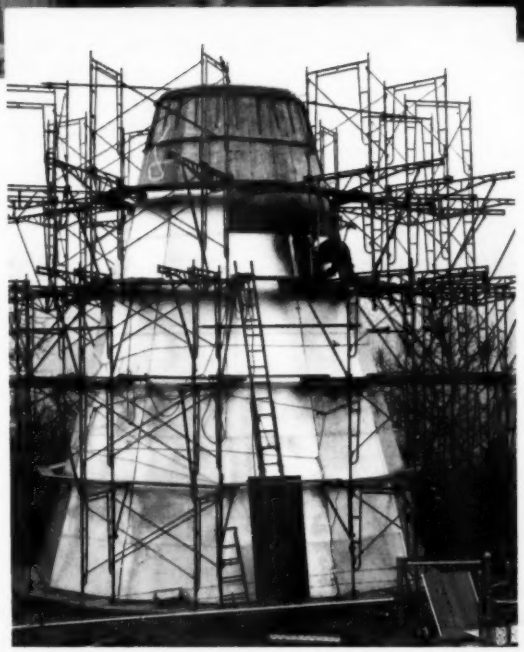


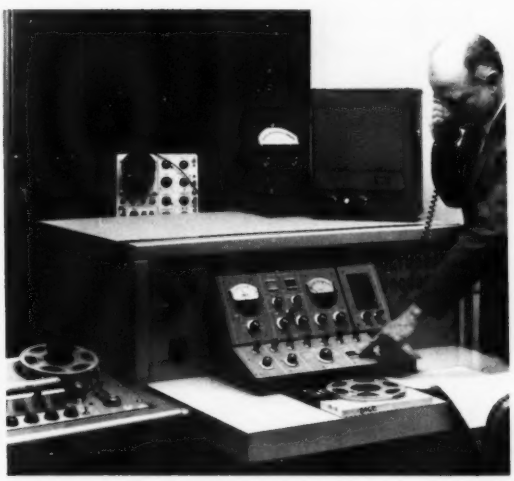
Photo 1 *The earth's granitic basement--the granite layer found at varying depths under the earth's surface--is an electrical conductor. Its effectiveness as a conductor depends on the absence of faults and moisture. In some areas of the country, an electrical signal can be propagated through this granitic layer over a distance of many miles. AFCRL is investigating the use of this granitic layer from the standpoint of achieving hardened, short-distance communications. In New Hampshire, the earth's granitic basement is found at the surface, and many AFCRL experiments, consisting of placing antennas within this granitic structure, take place in this area.*

Photos 2 & 3 *Under construction at an AFCRL field site in Waltham, Mass., is a high-precision, 29-foot millimeter-wave antenna. Photo #2 shows the mount for this antenna under construction by an AFCRL contractor. Photo #3 shows the tower on which this antenna mount will be placed. With this new antenna, which will be put into operation this summer, AFCRL will conduct research in millimeter-wave communications and in radioastronomy.*

some visible aspects of AFCRL research

Photos 4 & 5 *In eastern Massachusetts, AFCRL maintains a four-station sferics monitoring network. The sferics electromagnetic signals--picked up by three outlying stations of this network--are transmitted automatically to the central station shown in picture #4. By comparing the wave form of the sferics detected at the various stations, it is possible to measure the distance and general location of the original lightning stroke. Photo #5 shows some of the equipment inside the trailer located at the main sferic station.*

Photo 6 *Control console of AFCRL's vocoder is shown. A vocoder is used to process speech signals. By such processing, it may be possible to reduce the band width to transmit human speech to about 50 cycles. (This compares with the 3,000-cycle band width of a standard telephone line.) This results in transmissions over a greater distance for a given amount of power--and a great saving in channel capacity.*



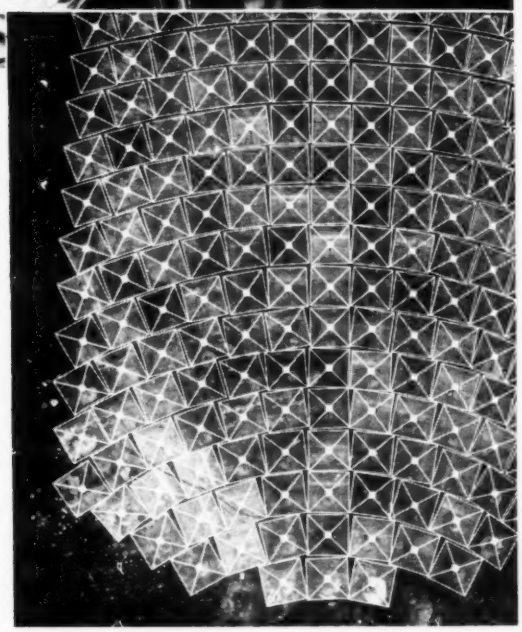


Photo 7 By firing a beam of electrons into the atmosphere, it is possible to measure atmospheric density on the basis of the X-rays produced by the collisions of electrons with atmospheric particles. Laboratory Brehmsstrahlung apparatus is used for calibrating Brehmsstrahlung devices carried aboard rockets. Electron gun being connected will fire into partially evacuated chamber, simulating gas densities of the upper atmosphere.

Photo 8 AFCRL's experimental multiplate antenna is shown as it appears from the top of the feed tower. The over-all antenna measures some 70 by 120 feet and consists of scores of five-foot square panels. The test model is being used to evaluate a proposed high-gain, high-resolution antenna consisting of some 5,000 plates each measuring 20 feet square. The proposed antenna would have an aperture of almost one half mile.

to our readers

Requests for further information should be directed to the individual or laboratory of origin (except for those from Latin America).

Addresses are as follows:

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
Attn: CRI
Laurence G. Hanscom Field, Bedford, Massachusetts 01731

AEROSPACE RESEARCH LABORATORIES
Attn: ARB
Wright-Patterson Air Force Base, Ohio 45433

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
Attn: SRGL
Tempo D Building
4th and Independence Avenue, S.W., Washington, D.C. 20333

OFFICE OF RESEARCH ANALYSES
Attn: ORR
Holloman AF Base, New Mexico 88330

Requests for further information from institutions and individuals in Latin America should be addressed to:

LATIN AMERICAN OFFICE AEROSPACE RESEARCH
U. S. EMBASSY
Rio de Janeiro, Brazil

Detailed documentary reports may be obtained from:

OFFICE OF TECHNICAL SERVICES
U.S. Department of Commerce, Washington, D.C. 20230

DEFENSE DOCUMENTATION CENTER FOR SCIENTIFIC AND TECHNICAL INFORMATION*
Cameron Station, Alexandria, Virginia 22314

* Qualified requestors